Zinc Battery Technology II
Will Zinc Energize the Energy Storage Revolution?

# What is the Market Potential for Zinc Battery Technology?

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NAATBatt INTERNATIONAL

MUSTANG PRAIRIE ENERGY

# Speaker

**Richard Baxter - President**
**Mustang Prairie Energy**

President of Mustang Prairie Energy bridging the financial and technical sides of the storage industry for investors, lenders, developers, and manufacturers

## Energy Storage Financing

- Energy Storage Financing: A Roadmap for Accelerating Market Growth, SAND2016-8109
- Energy Storage Financing: Performance Impacts on Project Financing, SAND2018-10110
- Energy Storage Financing: Advancing Contracting in Energy Storage, SAND2019-12793
- Energy Storage Financing: Project and Portfolio Valuation, SAND2020-xxxx

## Energy Storage System Pricing

- Lazard Levelized Cost of Storage, LCOS1.0, 2.0, 3.0 (pricing survey & capital cost modeling)
- Energy Storage Pricing Survey: 2018 (SNL, unpublished)
- Energy Storage Pricing Survey: 2019, SAND2019-xxxx

## Author

- PennWell - *Energy Storage: A Nontechnical Guide*

## Board Member

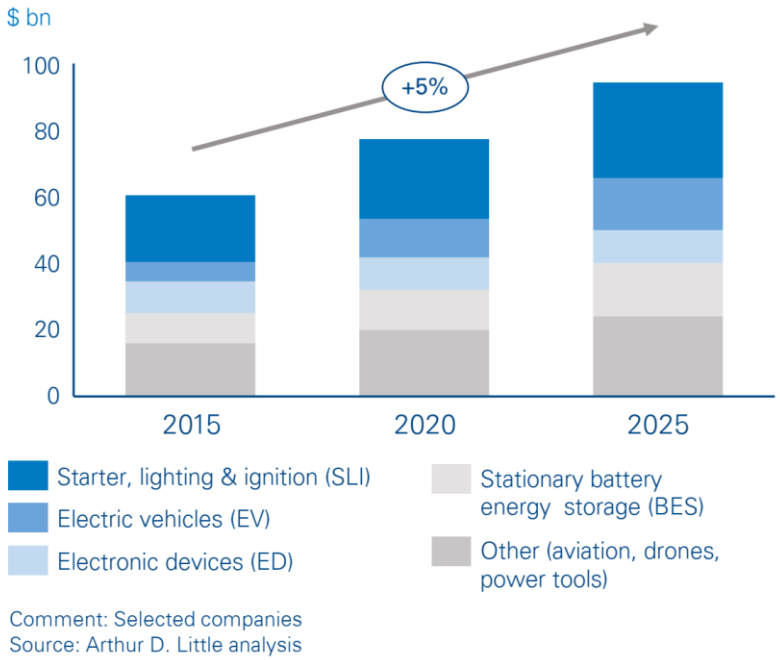
- Former: NovoCarbon Corporation (TSX-V: GLK) - Chairman
- Former: Energy Storage Association (ESA)
- Former: Charitable Foundation of the Energy Bar Association

## Executive Director

- Advancing Contracting in Energy Storage (ACES) Working Group
- ESA Best Practice Guide

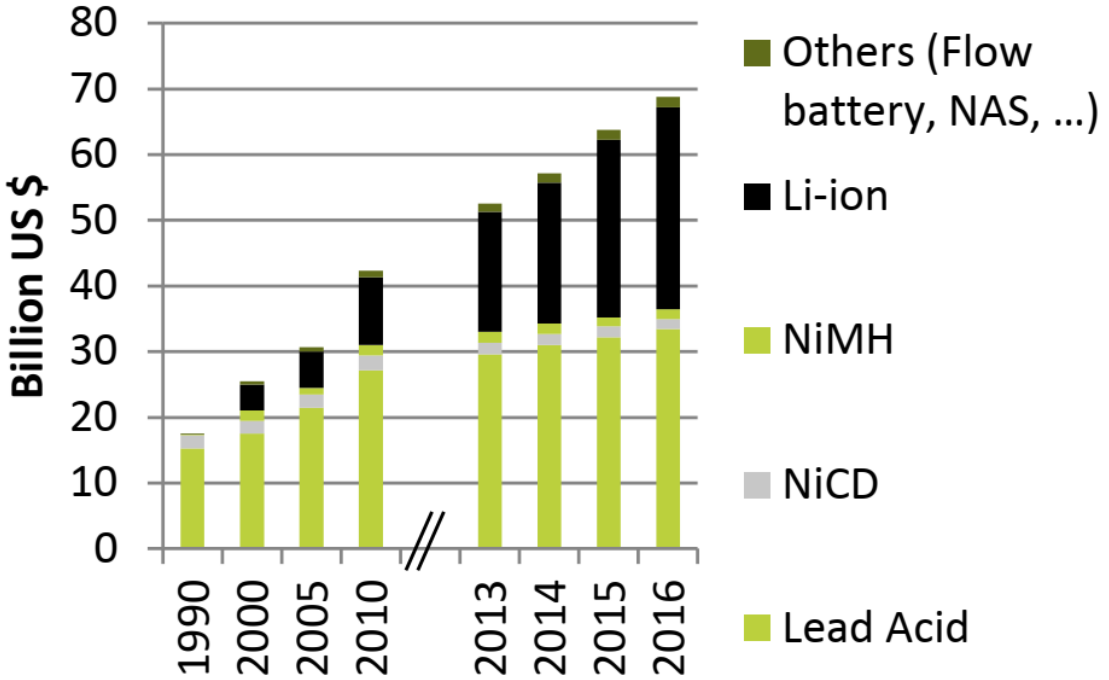
# Global Rechargeable Battery Market

## Sector Market Growth




Comment: Selected companies
Source: Arthur D. Little analysis

## Chemistry Breakout




Source: Avicenne

# Competing with Incumbents

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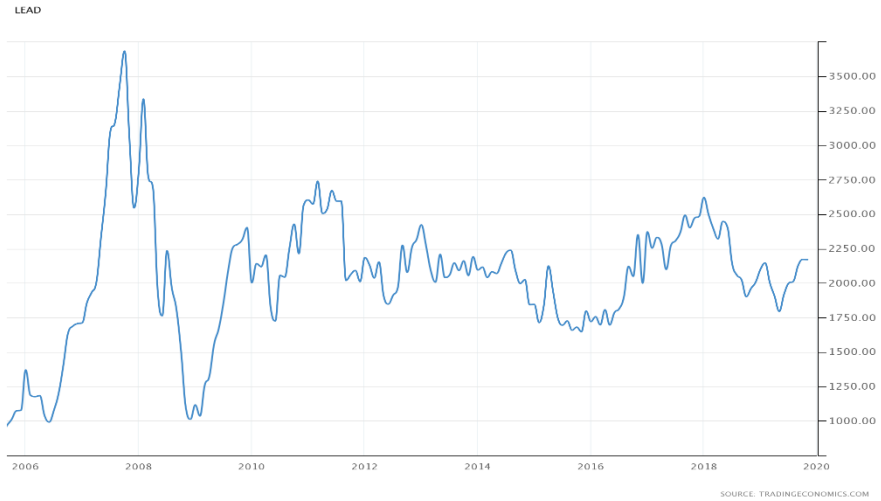
**Lead**

- Raw Metal Input Price Stability
- Changes to Battery Pricing Structure
- Increasing Cost of Recycling

Future Issues

- Reliant on Replacement Market
- Capability Improvements: Carbon

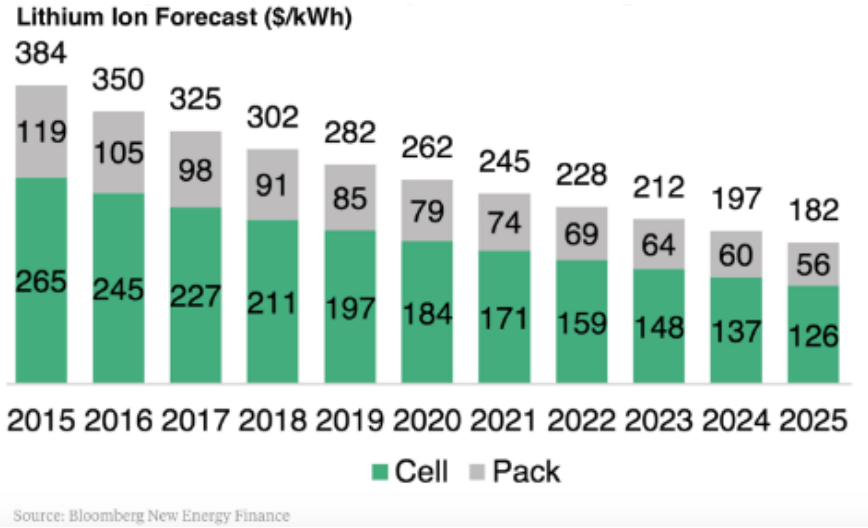



**Lithium**

- Continued Price Decline
- Automotive Market Dominates (Energy, not Power)
- Purchasing Volume Dictates Price

Future Issues

- Safety: Liability / Insurance
- Availability



# Advantages of Zinc

## Cost
- Low Material Metal Price
- Ease of Use/Handling
- Longer Useful Lifespan in Battery Applications

## Recycling
- 30% is Recycled
- 80% Reclamation Rate
- Waste Stream Improvements

## Availability
- China Major Producer / Self Use
- Global Production Base & Availability

## Safety
- Little Disposal / Recycling Issues
- No Similar Fire / Off-Gassing as with Competitors


| | Mine production[10] 2017 | Mine production[10] 2018[e] | Reserves[11] |
|---|---|---|---|
| United States | 774 | 790 | 11,000 |
| Australia | 842 | 940 | [12]64,000 |
| Bolivia | 473 | 520 | 4,800 |
| Canada | 344 | 340 | 3,000 |
| China | 4,400 | 4,300 | 44,000 |
| India | 833 | 800 | 10,000 |
| Kazakhstan | 330 | 390 | 13,000 |
| Mexico | 674 | 650 | 20,000 |
| Peru | 1,470 | 1,600 | 21,000 |
| Sweden | 251 | 220 | 1,400 |
| Other countries | 2,140 | 2,300 | 33,000 |
| World total (rounded) | 12,500 | 13,000 | 230,000 |

**World Resources:** Identified zinc resources of the world are about 1.9 billion tons.

Source: USGS

# Approaching the Market: Sales Channel

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**Replacement Market**

Existing Chemistry
- Dominates Existing Market
- Infrastructure Critical

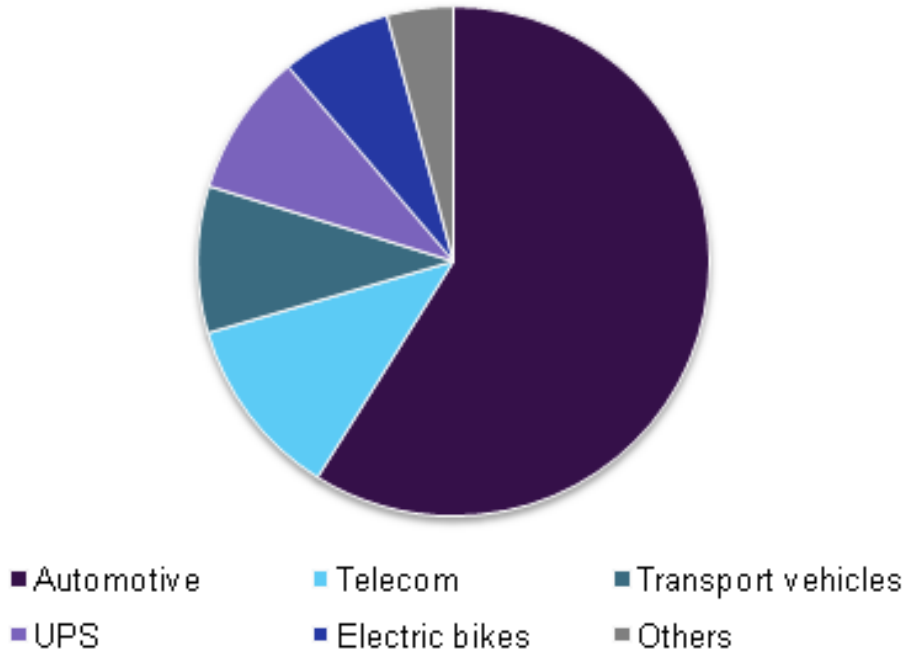
Competing Chemistry
- Form-Fit Replacement
- Payback Period
- Price
- Capabilities
- Lifespan
- Ancillary Impacts

**New System / Facility**

Existing Market
- Legacy Designs
- Support Infrastructure

Greenfield
- Regulatory
- Codes & Standards
- Unit Economics
- Process Economics
- Impact on Facility Design

**Global lead acid battery market by application, 2015 (%)**



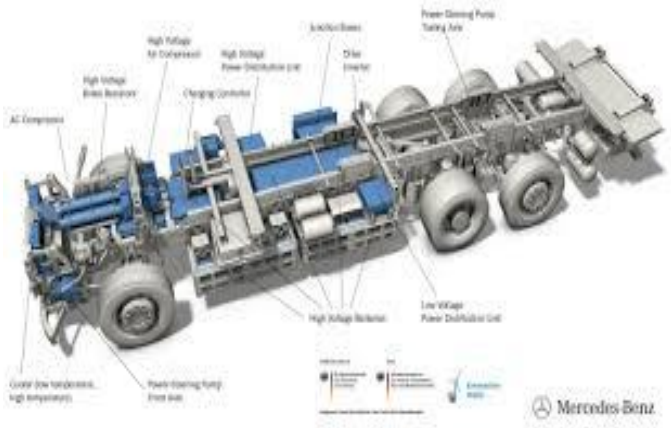

Source: Grand View Research

# Market & Opportunities

## Consumer


Existing Supply and Mfg. Base

## Vehicle



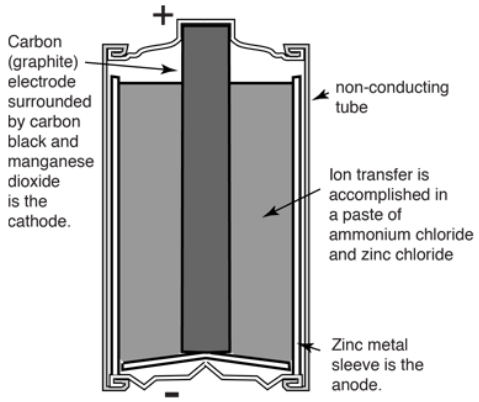

Rethinking the Powertrain

## Stationary

Emerging Distributed Networks

# Consumer: Provides Strong Industrial Manufacturing Base

## Carbon Zinc

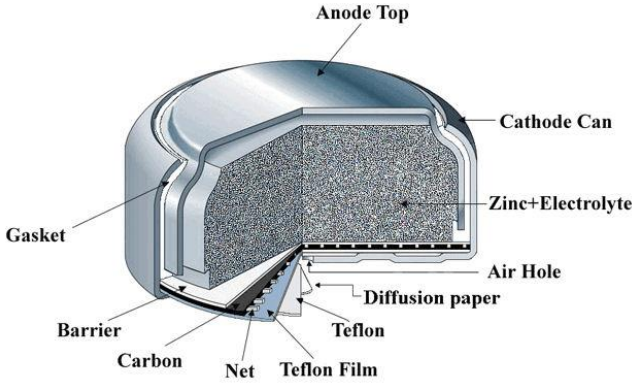



Source: Hyperphysics.phy-astr.gsu.edu

### Sustained Use

- $1.7 Bn Global Market / Stable
- Low Cost
- Acceptable Shelf Life
- Disposable

## Zinc Air




Source: Corrosion-doctors.org

### Continued Growth

- $1.4 Bn [2017] - $2.8 Bn [2025]
- Medical – Hearing aids
- Signage / Controls
- High Energy Density
- Stable – Environmental Conditions
- Lightweight

# Vehicle: Trucking

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## Target Applications

- Primary: Anti-Idle
- Secondary: Hybrid Drivetrain
- Ancillary: Automotive Start-Stop (Mirco-hybrid)

## Market Size

- $2.5 Bn [2018]

## Growth Drivers

- Emissions / Fuel Savings
- Hybrid vs. Electric Trucking

## Challenges

- APU Vendors / Truck OEM

## Zn Battery

- Lifespan
- Energy Density (Weight)
- Wider Temperature Range/Lower Cooling Load

**What does extended idling cost?**

| Based on: Medium-Duty Diesel Truck using approx. 0.4 – 0.6 gal./hr.[1] @ $2.75/gal. | | | | |
|---|---|---|---|---|
| 1 Truck – Daily Idling Time | 1 Truck – Daily Fuel Cost | 1 Truck – Annual[2] Fuel Cost | 10 Truck Fleet – Annual Fuel Cost | 25 Truck Fleet – Annual Fuel Cost |
| 30 minutes | $0.68 | $179 | $1,790 | $4,475 |
| 1 hour | $1.38 | $358 | $3,580 | $8,950 |
| 2 hours | $2.75 | $715 | $7,150 | $17,875 |

| Based on: Heavy-Duty Diesel Truck using approx. 0.9 gal./hr.[1] @ $2.75/gal. | | | | |
|---|---|---|---|---|
| 1 Truck – Daily Idling Time | 1 Truck – Daily Fuel Cost | 1 Truck – Annual[2] Fuel Cost | 10 Truck Fleet – Annual Fuel Cost | 25 Truck Fleet – Annual Fuel Cost |
| 30 minutes | $1.24 | $322 | $3,220 | $8,050 |
| 1 hour | $2.48 | $645 | $6,450 | $16,125 |
| 2 hours | $4.96 | $1,290 | $12,900 | $32,250 |

**NOTE:** Costs do not include increased maintenance for engine wear caused by extended idling.

Source: IdlefreeVT.org

# Vehicle: Industrial Truck / Lift Truck

**Target Applications**
- Lift Truck
- Industrial Truck/Tug
- Forklift
- Mining

**Market Size**
- $4.0 Bn [2018]

**Growth Drivers**
- Forklift – 2/3 Electric
- Hybrid vs. Diesel
- Limited Warehouse Support Infrastructure

**Challenges**
- Lead: Charging Time
- Lead: Infrastructure Needs
- Lithium: Abuse

**Zn Battery**
- System Cost
- Lifespan
- Environmental


# Vehicle: Marine

**Target Applications**
- Tug
- Ferry / Cruise
- Military (Navy)

**Market Size**
- Defense: $2.4 Bn [2018]
- Marine: $2.2 Bn [2018]
- Marine: $4.5 Bn [2023]

**Growth Drivers**
- Emissions / Operating Limitations
- Fuel Savings
- Hybrid vs. Diesel

**Challenges**
- Lead: Handling
- Lithium: Environmental Conditions

**Zn Battery**
- Lower Initial Cost
- Lower Lifecycle Cost
- Higher Energy Density
- Environmental
- Safety

Silver Zinc
- High Energy Density
- Reliability
- Safety


# Stationary: UPS

**Target Market**
- Data Center
- Commercial
- Utility

**Market Size (Data Center)**
- $4.5 Bn [2018]
- $6.5 Bn [2023]

**Growth Drivers**
- Cloud Computing
- Reliability & Resiliency
- Leveraging Existing UPS Architecture

**Challenges**
- Lead: Additional Applications
- Lithium: NFP 855
- Sales Channel Turnover

**Zn Battery**

Data Center
- Reliability
- Life Cycle Cost
- Energy Density
- Environmental / No Cooling
- Safety

# Stationary: Telecommunication

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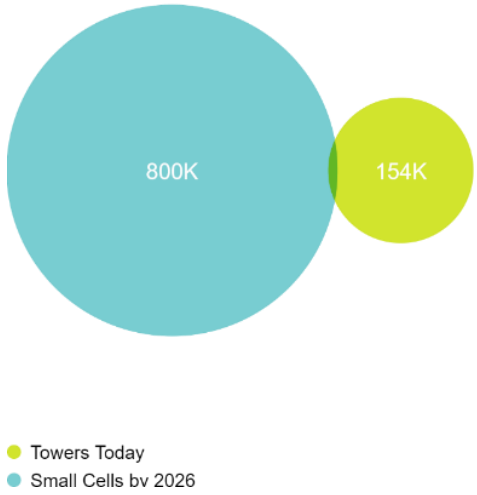
**Target Applications**
- Central Exchange
- Cell Towers
- 5G

**Zn Battery**
- System Cost
- Lifespan
- Environmental

**Market Size**
- $4.5Bn [2018]
- 150,000 Cell Towers -> 800,000 5G Stations

**Growth Drivers**
- Wireless Devices
- Reliability

**Challenges**
- Reliability
- Support Needs
- Endurance Capability
- Environmental Conditions




# Stationary: Grid

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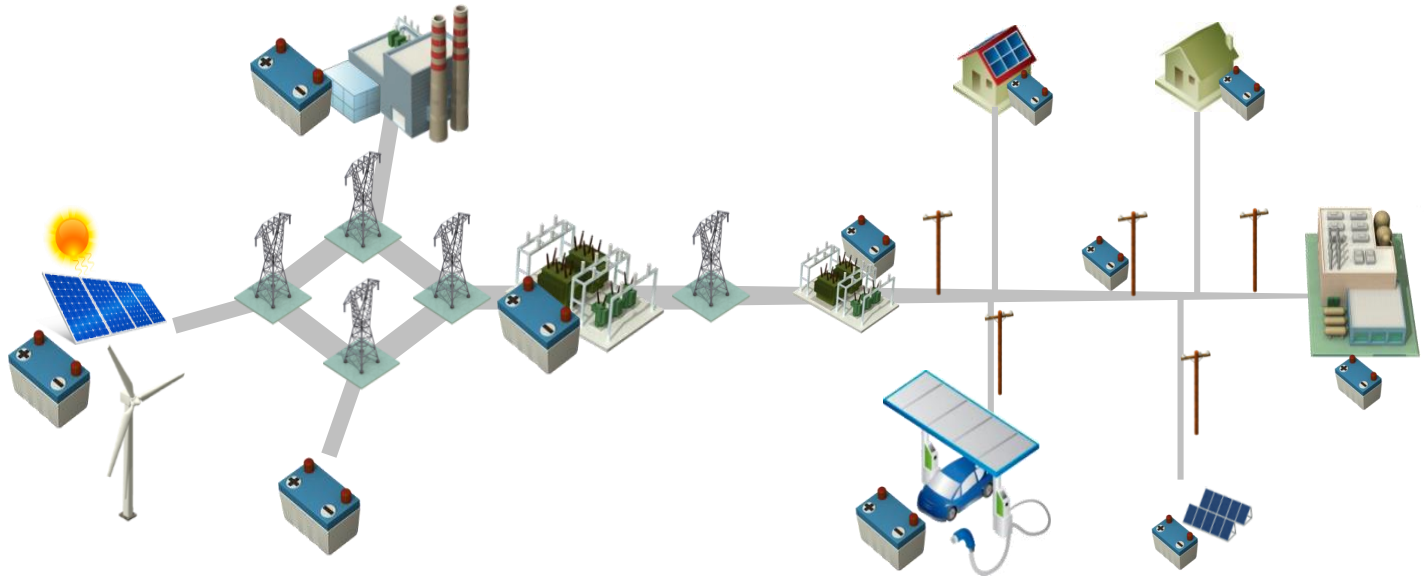
**Target Applications**

- Utility: Capacity (2 Hrs.)
- Renewable: Time Shift / Balancing (2 Hr. – 8 Hr.)
- Microgrid: Balancing (2 Hr. – 8 Hr.)
- BTM: Cost of Service (2 Hr. – 8 Hr.)

**Market Size**

- $3.2 Bn [2017]
- $103 Bn [2030]



**Growth Drivers**

- Movement toward Distribution
- Reliability
- Grid-interactive

**Challenges**

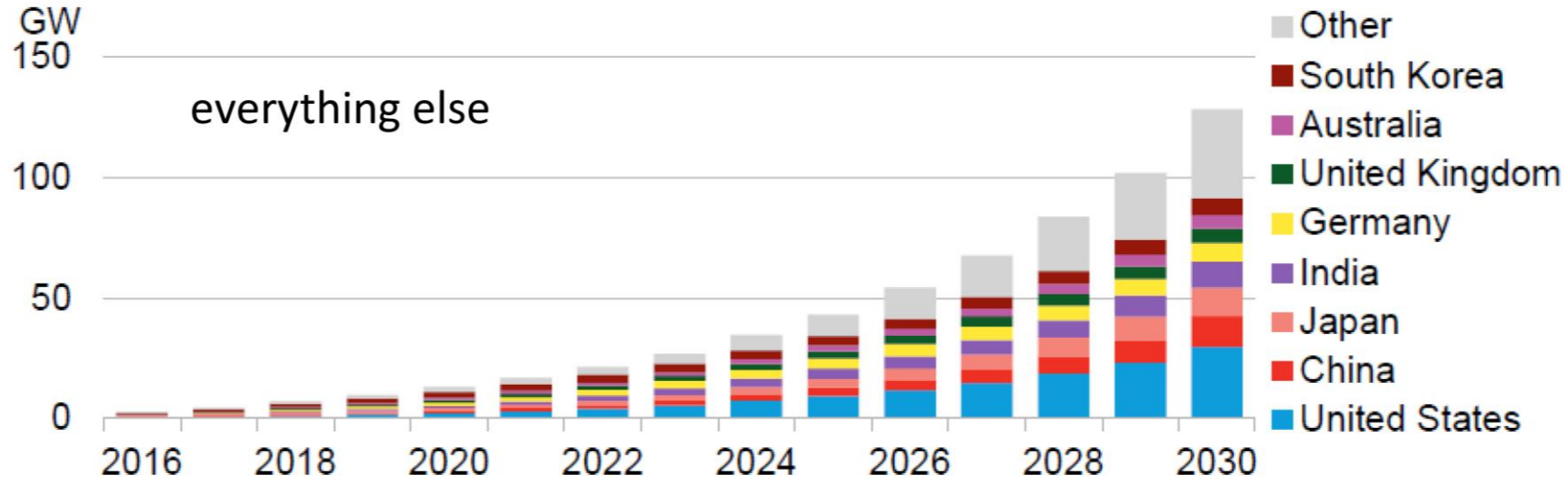
- Lithium: Safety
- Lithium: Lifespan in Active Usage

# Stationary: Grid Market Growth

**Global Grid Storage Market:**

- 2017 – $3.2 billion
- 2030 – $103 billion
- 2030 – 125 gigawatts, 305 gigawatt-hours

Eight countries will lead the market, with 70 percent of capacity to be installed in the U.S., China, Japan, India, Germany, U.K., Australia and South Korea.




*Source: Bloomberg New Energy Finance*

# Stationary: Grid: Renewable Energy

**Target Applications**

- Grid Connected Solar: Intermittency
- BTM Solar: Local Generation
- Microgrid: Balancing Load
- Remote Solar: Manage Load

**Growth Drivers**

- Issues with Legacy Thermal Generation
- Reliability / Resiliency
- Cost Effectiveness of Solar
- Going Off-Grid, not Off-Internet

**Challenges**

- Environmental Conditions
- Lifespan
- Energy Throughput


# Zinc Battery Technology II
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## Thank you

Richard Baxter
Mustang Prairie Energy